

Development of the Autonomous Aerosonde

PI Dr. Greg J. Holland
Bureau of Meteorology Research Centre,
PO Box 1289K, Melbourne, Vic 3001, Australia
Ph: +61 3 9669 4501, Fax: +61 3 9669 4660
g.holland@bom.gov.au

Co-PI Dr. Tad McGeer
The Insitu Group,
401 Bingen Point Way, Bingen, Washington 98605
Ph: +509 493 8600, Fax: +509 493 8601
Insitu@gorge.net

Co-PI Greg Tyrrell
Environmental Systems and Services Pty Ltd,
PO Box 939, Hawthorn, Vic 3122, Australia
Ph: +61 3 9864 5300, Fax: +61 3 9822 8028
gregt@esands.com

Co-PI Dr. Kendal McGuffie
Bureau of Meteorology Research Centre,
PO Box 1289K, Melbourne, Vic 3001, Australia
Ph: +61 3 9669 4501, Fax: +61 3 9669 4660
kendal@phys.uts.edu.au

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LONG-TERM GOALS

Our long-research goals are to develop improved understanding and prediction of the atmosphere, with particular emphasis on severe weather. A special emphasis is placed on coastal zones and observing-system research.

OBJECTIVES

To develop the autonomous Aerosonde as a flexible observing platform for providing economical observations in remote locations, including tropical cyclones.

APPROACH

The autonomous Aerosonde is being developed to provide a flexible and low cost observing platform for a wide variety of needs, most notably in the field of meteorology. The approach taken during the development program has been to combine engineering development with extensive field testing which has included participation in a number of international field programs. By adopting this approach, it is hoped that the end result will be a product that is finely tuned to the needs of the end-user.

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The major technical complexity lies with the development of an engine to operate at our design altitude of 14 km. In recognition of this we have proceeded along a two-phase development path:

- Phase I, which is well advanced, is to produce an operational platform with all design characteristics except that of high altitude. This aircraft is very close to becoming operational with a capacity to operate to 5 km altitude with a range of >3000 km and >30 hour endurance.
- Phase II will consist of system refinement and a major engineering effort to construct a supercharged engine suitable for operation to the design altitude. Work in this area has progressed steadily and it is expected that first versions of the high altitude powerplant will be ready for testing in 1999.

The project was initiated by support from ONR and has been operating as a full fledged development program for the last 3 years. This development activity has occurred as a collaboration between Environmental Systems and Services Pty Ltd in Melbourne, Australia; the Insitu Group in White Salmon, Washington; and the Australian Bureau of Meteorology. Dr. Greg Holland is the Technical Director of the program and Dr. Tad McGeer is the Chief Engineer.

WORK COMPLETED

During the last 3 years of the Project, the results of the engineering effort have been evident by the achievements of the Aerosonde system in field programs. Not only has the engineering development occurred under user scrutiny, but the ability for the system to operate in a wide range of conditions from hot and humid monsoon zones to cold climates has been extensively tested. As we have progressed, the reliability and versatility of the system has improved steadily. Facts and figures of Aerosonde field programs are displayed in Fig.1.



Figure 1: Aerosonde Field Performance Statistics (November 1995 to October 1998)

Field programs have included: the Maritime Continent Thunderstorm Experiment north of Darwin in late 1995; trials in the marine boundary layer off Cape Blanco, Oregon in July 1996; sea-breeze

trials off northwestern Australia in August, 1996; demonstrations for the Canadian AES out of Vancouver Island, Canada in 1997 and 1998; a 6 week operational demonstration for the Australian Bureau of Meteorology off the Western Australian coast in early 1998; and participation in the South China Sea Monsoon Experiment in May 1998. While field work has demonstrated the concept and capabilities of the Aerosonde system, there is still much work required to increase our reliability and operational limits.

Over 30 aircraft have now been built and used for operations and testing. Eight have been supplied to the University of Washington and CIRPAS under ONR SBIRs. A small production facility has now been established to handle all future aircraft production and allow the development team to concentrate on R&D. Further, an international facility for operating Aerosondes is at the advanced development stage for establishment in FY 2000.

RESULTS

After several years of gestation and a concentrated 3-y development program, the Phase I Aerosonde moved towards operational mode in 1998. The year started with a full operational trial undertaken by the Australian Bureau of Meteorology from Port Hedland on the northwest coast of Australia. This trial was to establish that the Aerosonde development program had achieved its stated development milestones. The specific goals were to:

- Provide a full test of the Phase I Aerosonde system;
- Demonstrate the degree of reliability and usability of the aircraft;
- Establish operational benchmarks; and
- Provide useful real-time data to Bureau of Meteorology operations.

All of these were achieved. After the initial establishment and testing phase, we moved into a routine of the type of operations that are expected to become the normal for Aerosondes. As shown in Fig. 2, launch and recovery were at a designated site in the Cargill Salt facility near Port Hedland. We were provided an extensive area for operations offshore by the Australian Civil Aviation Safety Authority, together with a corridor for sea breeze and related flights. After launch and initial checkout, aircraft command was transferred to the Regional Forecasting Centre in Perth, around 1300 km from the operations area. All operations were commanded from Perth until it was time to land, when control was passed back the crew at Cargill Salt. Full details of this mission are contained on the web site. One example mission into a severe microburst is provided here.

On Saturday 24 January, we brought an Aerosonde operating offshore back to sample the environment of a set of moderate convective cells that had developed along the sea breeze front and moved into the area from the south east. Aircraft control was from the Cargill Salt site. The sea breeze was quite strong and was observed to have very strong vertical wind shear at the top of around 20 ms^{-1} in 100-200 m. The Aerosonde encountered moderate to severe turbulence in this layer, and Kelvin Helmholtz billows were observed to grow into long roll clouds on occasions. During the missions, a small convective cell developed rapidly over Cargill, with heavy rain experienced for several minutes. The control site was then hit by a classic wet microburst. Subjective estimates were of winds in excess of 70 kt and the control building, a demountable weighing in excess of 1 tonne with four people inside, was slewed around and moved approximately 1 m before it was arrested by a cable.



Figure 2: Aerosonde Operational Trial, Western Australia, January – February 1998.

The Aerosonde flew into a downdraft of around 12 ms^{-1} at approximately the same time. It had previously flown into a strong wind shift of 20 ms^{-1} in less than 1 s, which we originally attributed to the microburst, but may have been the wind shear at the top of the sea breeze. Forced descent occurred to an altitude of 250 m (Fig. 3), where the aircraft experienced a massive hit, which we believe was the main microburst outflow. The lateral acceleration exceeded 4g, with a 30 ms^{-1} speed change in 1.5 s. After a second encounter with the downburst, the Aerosonde was directed to the south away from the danger area. Unfortunately, the engine subsequently quit, leading to a crash landing in one of the brine lakes at Cargill Salt.

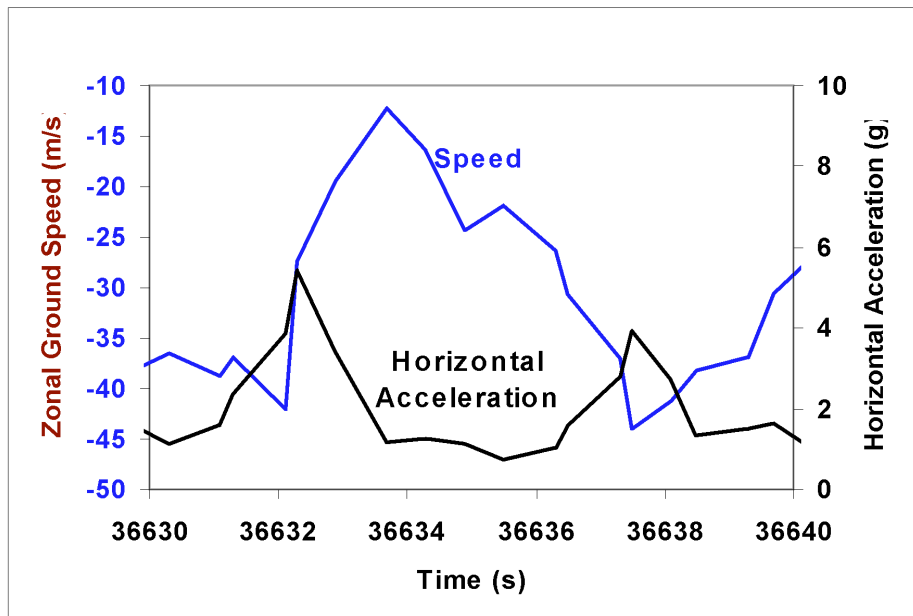


Figure 3: Zonal groundspeed and horizontal acceleration plots for an Aerosonde encounter with a microburst during the Operational Trials in Western Australia.

The Port Hedland trial was followed by a series of flights from Vancouver Island for the Canadian AES, and from Dongsha Island for the South China Sea Monsoon Experiment. A highlight was provided in August when Aerosonde "Laima" became the first robotic aircraft to cross the North Atlantic Ocean.

Reliability issues have governed the direction of the development throughout this period. Significant improvements have followed in the performance of the powerplant. While this field experience has been invaluable, we must take stock of what we have learned and spend some time incorporating changes to produce a more reliable product in 1999.

IMPACT / APPLICATIONS

We consider that the Aerosonde will open up a new era in economical aircraft operation, particularly in remote and hazardous areas. As discussed in Holland et al. (1992) the Aerosonde enables flexible operations in meteorology from routine soundings to observing severe weather. One particularly significant application is for Aerosondes to be deployed as a major component of an adaptive observing strategy. Apart from meteorology, the Aerosonde has potential to be used in a number of other applications including geomagnetic survey, search and rescue and fire fighting.

The potential is emphasized by widespread endorsement of the Aerosonde by international organisations including the WMO Commission for Atmospheric Sciences, the International Council of Scientific Unions, the Executive Committee for the International Decade for Natural Disaster Reduction, and the ESCAP/WMO Typhoon Committee.

TRANSITIONS

Results from the past 3 years have lead the developers to believe that the Aerosonde will better serve the meteorological community if operated by a facility specialising in providing an Aerosonde service. During the next year, it is anticipated this facility will become established and commence operations of Aerosondes in a mode that can be described as a hybrid between development and full operations. This will enable us to continue the program of establishing a robust system whilst providing close to full field observing capacity. During this transition period, aircraft will not be made available for general sales.

RELATED PROJECTS

Aerosondes are being considered for meteorological programs in Hawaii, Tasmania, Nauru, Barrow, Alaska as well as a Typhoon Reconnaissance Trial in the Western Northern Pacific during the coming year.

REFERENCES

Holland, G.J., T.McGeer and H.Youngren, 1992: Autonomous Aerosondes for economical soundings anywhere on the globe. *Bull. Amer. Met. Soc.*, **73**, 1987-1998.

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